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Patentanmeldung Nr. Patent application No. Demande de brevet n°

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Lens driving device for optical and/or write system and optical read/write system

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Lens driving device for optical read and/or write system and optical read/write system

FIELD OF THE INVENTION

The invention relates to a lens driving device for an optical read and/or write system, comprising a mechanical structure having an objective lens, and an actuator for control of the lens position by acting on the mechanical structure.

The invention also relates to an optical read and/or write system comprising a lens driving device comprising a mechanical structure having an objective lens, and an actuator for control of the lens position by acting on the mechanical structure, the system further comprising a controller means for generating a control signal for the actuator, the actuator acting in response to the control signal.

BACKGROUND OF THE INVENTION

Lens driving devices as well as optical read and/or write systems comprising lens driving device are known. An optical read and/or write system reads information recorded on a optical medium, e.g. on a disk, using laser light to read/write a signal optically and/or writes information on said optical medium. The lens driving device for such an optical read and/or write system drives an objective lens while position control of the lens, e.g. focus control and tracking control, are executed in accordance with the driving signals supplied to driving actuators, e.g. coils consisting of a focus coil and tracking coil wound on a holder provided with the objective lens. The lens driving device comprises a mechanical structure with an objective lens, usually on a holder usually being suspended by suspension means. Actuators, for instance tracking and focusing coils on or near the mechanical structure e.g. on or near the lens holder in co-operation with magnets on a fixed part allow the position of the lens to be controlled, e.g. the lens holder can be moved in a radial direction (tracking) and a vertical direction (focusing). Alternatively the device may have coils on a fixed part and magnets mechanical structure, e.g. on the lens holder. The lens driving device generally has respective resonance frequencies in the focus control and tracking movement, each resonance having a certain mode-shape (characteristic movement of the structure at a resonance frequency). These natural resonance frequencies (eigenfrequencies) depend a.o. on physical shape of the mechanical structure. This shape also determines the anti-resonances, e.g.

frequencies where the movement of the mechanical structure at the position of the lens is very small due to cancelling effects of the different mode shapes.
Such natural resonance and anti-resonance frequencies are typically situated around or slightly above 1 to 10 kHz.

In order to follow the tracks on the optical medium as accurate as possible the bandwidth of the total system comprising the actuated mechanical system and a feedback controller must be as large as possible. However, the combinations of resonances and anti-resonances as described above, are a limit for this bandwidth. In the case of these resonance and anti-resonance combinations it is in practice not possible to design a simple (PID or PI-lead/lag) feedback controller, such that the total system has a loop gain that is smaller than 1 for the frequency where the phase is -180°, while the bandwidth of this system is in the region of the resonance/anti-resonance peaks. That is, if the loop gain comes close to –1, the system gets unstable and uncontrollable.

One way of avoiding these problems is to design the mechanical structure such that its natural resonance frequencies lie at very high frequencies, such that the bandwidth of the controller can reach its specifications. The lens driving device is designed so that each higher mode resonance is out of each servo band. Namely, by designing the servo band necessary for actual servo control at an upper limit of e.g. 2 kHz - 5 kHz, the control system is made unaffected by the phase shift in the vicinity of the natural resonance frequency. EP 1 079 377 discloses a design aimed to achieve an increase in natural resonance frequency. In recent years however, the disk read and/or write systems are operated at a high rotating speed of a disk that is several times the up till then standard rotating speed of the disk. This increases the speed with which a signal is read and/or written by the lens driving apparatus for the disk player, and it also increases the driving speed, and thereby the driving frequencies of the drive. Thus there is a tendency that the upper limit in the servo band of the control system increases, driving a need to increase the natural resonance frequency of the mechanical structure. This makes it often difficult to reach very high resonance frequencies, because of limitation on the space that can be occupied by the mechanical structure, or notwithstanding an increase in natural resonance frequency, the increase in read/write speed also increases the upper limit (in frequency) of the servo control, to a frequency approaching a natural resonance frequency.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a lens driving device of the type described in the opening paragraph and an optical read and/or write system comprising a lens driving device with improved high frequency characteristics to reduce one or more of the indicated problems.

To this end the lens driving device comprises a further actuator acting on the mechanical structure for generating at a frequency range a motion of or in the mechanical structure to at least partially compensate motion generated by the first mentioned actuator.

To this end the optical read and/or write system comprises a lens driving system comprising a further actuator acting on the mechanical structure for generating at a frequency range a motion of or in the mechanical structure to at least partially compensate motion generated by the first mentioned actuator and the controller comprising means for generating a compensation signal for said further actuator.

The further actuator excites the mechanical structure at the same resonances as the first mentioned actuators to compensate the motion caused by the first mentioned actuator. In this manner the resonances are actively cancelled, and the harmful oscillations are avoided. The lens driving system can be operated up to high frequencies.

In a preferred embodiment the further actuator comprises a piezo electric element. Within the broadest concept of the invention the actuators may be e.g. a coil in combination with a magnetic system or e.g. a piezo electric element. Use of a piezo electric element is preferred because the further actuator is used at relatively high frequencies (the higher resonance frequencies), for which piezo electric elements are well suited, and in general the additional weight caused by the further actuator is preferably small, and the weight of piezo electric elements is in general smaller than the combined weight of a coil and magnet system. Furthermore, a piezo electric element is in general smaller than an electromagnetic actuator comprising a coil and magnet system.

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Fig. 1 illustrates a scheme for an optical read and/or write system in accordance with the invention

Fig. 2 shows in a perspective view an embodiment of a lens driving device in accordance with the invention.

Fig. 3 shows in a perspective view another embodiment of a lens driving device in accordance with the invention

Fig. 4 shows in a perspective view a further embodiment of a lens driving device in accordance with the invention

Fig. 5 shows in a perspective view yet another embodiment of a lens driving device in accordance with the invention.

Fig. 6 shows a lens driving device in accordance with the invention

Fig. 7 illustrates in a graphical form the effects of the invention.

The figures are not drawn to scale. Generally, identical components are denoted by the same reference numerals in the figures.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Fig. 1 schematically describes some elements of a system in accordance with the invention. On a mechanical structure 1 a lens is attached to a lens holder (not shown in the scheme, see for examples following figures). Attached to or near the mechanical structure is an actuator 4, which receives a control signal CS from a controller (in this example in the form of a control circuit CC) . The input for the controller is an sensor output SO, which is in this example fed to a feedback controller (FC). These elements form the basic elements by which means the position of the lens on the mechanical structure is controlled. However, the mechanical structure 1 has natural resonance frequencies (eigenfrequencies).

In order to follow the tracks on the optical medium as accurate as possible the bandwidth of the total system comprising the actuated mechanical system and a feedback controller must be as large as possible. However, the combinations of resonances and anti-resonances as described above, are a limit for this bandwidth. In the case of these resonance and anti-resonance combinations it is in practice not possible to design a simple (PID or PI-lead/lag) feedback controller, such that the total system has a loop gain that is smaller than 1 for the frequency where the phase is -180° , while the bandwidth of this system is in the region of the resonance/anti-resonance peaks. That is, if the loop gain comes close to –1, the system gets unstable and uncontrollable.

One way of avoiding these problems is to design the mechanical structure such that its natural resonance frequencies lie at very high frequencies, such that the bandwidth of

the controller can reach its specifications. However, there is a limit to making the eigenfrequencies higher, especially in view of the constraints put on the design and the fact that the read/write speed becomes ever higher.

The invention aims to solve the above problems in a different manner. To this end the lens driving device comprises a further actuator on or near the mechanical structure for acting on the mechanical structure for generating at a frequency range a motion of or in the mechanical structure to at least partially compensate motion generated by the first mentioned actuator.

A further actuator 5,5a,5',5b is placed on or near the mechanical structure. It (they) will excite the mechanical structure at the same resonance frequencies as the actuator 4. By feeding a compensating controller signal COMPS to the further actuator(s) at a frequency range (to this end filters F may be provided) to the further actuator(s) as is shown in figure 1, unwanted resonance's can be compensated for. A gain G, which may be a tuneable gain, may be provided to set the gain for the compensation signal. The gains may be different for different compensating actuators. This is schematically indicated in Fig. 1 by gain G'. Preferably, the further actuator is designed such that it excites predominantly the resonance frequency that is to be cancelled.

By compensating of the motion of actuator 4, the system remains stable and controllable, also when a controller is designed such that the bandwidth of the system is near a resonance frequency of the mechanical system. It is remarked that electronically eliminating the problem by using in the control circuit a notch filter (a filter that is specifically tuned to stop a particular frequency) it can also be avoided that the system becomes unstable. However, such notch filters have to be tuned for each device, and furthermore, ageing and temperatures effects may cause in time a mismatch between the eigenfrequency and the frequency of the notch filter. In the invention such problems are smaller.

The filters used in the controller can be simple high pass filters, or band filters.

Fig. 2 shows schematically in a perspective view a lens driving device 1 in accordance with the invention. On a mechanical structure 3, in this exemplary embodiment a swing arm 3, a lens 2 is positioned. A force is generated by coil 4 in the focus direction and by coil 6 in the radial direction. To suppress (compensate for) unwanted resonance's of mechanical structure 3 an actuator, in this exemplary embodiment a thin piezo electric element 5 is attached to mechanical structure 3. The permanent magnets which cooperate with the coils in generation of the forces are not shown here. The coil may be positioned on

the movable mechanical structure, in which case a permanent magnet system is positioned on a fixed part of the device, or alternatively, the permanent magnet system is attached to the mechanical structure, in which case the coils are positioned on a fixed part of the device. It is preferred, however, that the coils are attached to, fixed to or form part of the mechanical structure 3. The weight of the mechanical structure is relatively less, which reduces the power dissipation and increases the resonance frequencies.

Fig 3. shows a second embodiment. This embodiment comprises the same mechanical structure as shown in Fig. 2 but for the fact that the piezo electric element 5 is divided in two separate zones 5a, 5b. By feeding these separate zones 5a, 5b through different filters i.e. at different frequency ranges (see Fig. 1) and/or by designing them such that more resonances are excited, more than one resonance can be compensated for.

Fig. 4 shows yet a third embodiment, similar to the embodiment shown in Fig. 2, but for the fact that focus movement is generated not by a coil 4, but by a thin piezo electric element 4', for instance glued on the bottom of the mechanical structure 2. The combination of piezo electric elements 5 and 4' makes the structure thinner and smaller, which is in itself an advantage. It is remarked that the invention is to understood to offer a route for reducing problems with resonance's. The invention is not to be so restrictively interpreted as not to be able to be combined with other measures to reduce problems with resonance's. For instance making the mechanical structure thinner and lighter (as in the example of Fig. 4) reduces the weight, thereby reducing power consumption. It also can lead to an increase in the resonance frequency, which is an advantage.

Fig. 5 shows yet a further embodiment of the a lens driving device in accordance with the invention. It comprises the same actuators as in the embodiment shown in Fig. 2, but now the compensating actuator 5' is an electromagnetic actuator, comprising a coil placed op top of the mechanical structure 3. A permanent magnet system (not shown here) for cooperation with the actuator 5' is attached to the fixed housing for the swing arm.

A fifth embodiment is shown in Fig. 6. It comprises a lens 2 on a mechanical structure comprising a lens holder 3a, hinges 3b and a base 3c. The focussing and radial movements are generated by electromagnetic actuators of which only the permanent magnet system 7 and the radial coils 8 are shown. The resonance of the hinges during focusing movement are reduced (compensated for) by piezo elements 9 on top of the hinges, while the resonances during radial movement are suppressed by piezo electric elements 10.

Finally Figs. 7A and 7B illustrate in a graphical form the effect of the invention. In this graph experimental results are shown for an embodiment as schematically

shown in Fig. 2. The horizontal axis denotes the frequency, whereas in the vertical direction gain (ratio of SO/CS in dB) is given (Fig. 7A), and the phase difference. Two lines are drawn, one (the solid line) without using a compensating actuator, the other (the dotted line) with use of a compensating actuator. Two resonance frequencies at which the phase lag decreases below -180^0 are indicated by peaks 71, a and b at around 1.4 kHz and around 5 kHz. These negative peaks in the phase cannot be compensated for by e.g. simple PID (Proportional Integral Derivative) or PI-lead/lag controllers and thus limit the bandwidth of the total system. A system with a bandwidth near these peaks 71a and b would be unstable. The dotted line show that use of the further actuator removes these peaks, and thereby removes the instabilities. It is remarked that in fact with a single actuator both of the first instabilities are removed. The inventors have found that, compared to when use is made of an electronic notch filter, the resonance suppressing effect is more stable. Temperature or ageing effects are smaller. Experiments have also shown that overcompensation does not pose a major problem, Overcompensation has an effect as shown in figures 7A and 7B for the second peak b. A phase lag (a negative phase difference) is turned into a positive phase difference , which can be seen by the fact that the negative peak (to below -180 degrees) is turned into a positive peak (above the -180° line). In fact supplying the further actuator with an overcompensating signal may be advantageous, since an added safety margin is then build in against instability. This forms an advantage of the invention, the compensating effect is robust, especially if a small overcompensation is used. Thermal effects and ageing effects have little influence. The filters can be broad band or high-pass filters (which are simple, cheap filters), the gain g can vary between a relatively large margin, while still a good result is achieved.

It is remarked that addition of the further actuators to the mechanical structure has in itself an effect on the resonance frequencies of the mechanical structure. Therefore the filter(s) F are chosen or set to match the mechanical structure with further actuators, as is (are) the gain(s).

While the invention has been described in connection with preferred embodiments, it will be understood that modifications thereof within the principles outlined above will be evident to those skilled in the art, and thus the invention is not limited to one or more of the described embodiments but is intended to encompass such modifications.

One such modifications is for instance an embodiment in which the gain(s) g are tuneable (i.e. they have means for setting the gain of the signal for the further actuator)

and the system has means for temporarily measuring for instance the phase lag within a frequency range, and retuning the gain in response to the measured phase lag.

The invention is embodied in each new characteristic and each combination of characteristics. Any reference signs do not limit the scope of the claims. The word "comprising" does not exclude the presence of other elements than those listed in a claim. Use of the word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements.

Within the concept of the invention a 'controller means' is to be broadly understood and to comprise e.g. any piece of hard-ware (such a controller, controller circuit), any circuit or sub-circuit designed for performing a controlling function as well as any piece of soft-ware (computer program or sub program or set of computer programs, or program code(s)) designed or programmed to perform a controlling operation in accordance with the invention as well as any combination of pieces of hardware and software acting as such, alone or in combination, without being restricted to the below given exemplary embodiments.

In short the invention may be described as follows:

A lens driving device (1) or an optical read and/or write system, comprises a mechanical structure (3) with an objective lens (2), and an actuator (4, 4', 6) for control of the lens position. The lens driving device comprises a further actuator (5, 5a, 5b, 5') on or near the mechanical structure to at least partially compensate motion generated by the first mentioned actuator (4,6).

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CLAIMS:

1. A lens driving device for an optical read and/or write system, comprising a mechanical structure having an objective lens , and an actuator for control of the lens position by acting on the mechanical structure, characterised in that the lens driving device comprises a further actuator on or near the mechanical structure for acting on the mechanical structure for generating at a frequency range a motion of or in the mechanical structure to at least partially compensate motion generated by the first mentioned actuator.

2. A lens driving device as claimed in claim 1, characterized in that the further actuator is designed such that it excites predominantly the resonance frequency that is to be cancelled.

3. A lens driving device as claimed in claim 1, characterised in that the further actuator comprises a piezo electric element.

4. A lens driving device as claimed in claims 1 or 2, characterised in that the actuator comprises a piezo electric elements.

5. An optical read and/or write system comprising a lens driving device comprising a mechanical structure having an objective lens, and an actuator for control of the lens position by acting on the mechanical structure, the system further comprising a controller means for generating a control signal for the actuator , the actuator acting in response to the control signal, characterised in that the lens driving device comprising a further actuator on or near the mechanical structure for acting on the mechanical structure for generating at a frequency range a motion of or in the mechanical structure to at least partially compensate motion generated by the first mentioned actuator and the controller means comprising means for generating a compensation signal for said further actuator.

6. An optical read and/or write system as claimed in claim 5, characterized in that the further actuator is designed such that it excites predominantly the resonance frequency that is to be cancelled.

7. An optical read and/or write system as claimed in claimed 5, characterised in that that the further actuator comprises a piezo electric element.

8. An optical read and/or write system as claimed in claimed 5 or 6, characterised in that the actuator comprises a piezo electric element.

ABSTRACT:

A lens driving device (1) or an optical read and/or write system, comprises a mechanical structure (3) with an objective lens (2), and an actuator (4, 4', 6) for control of the lens position. The lens driving device comprises a further actuator (5, 5a, 5b, 5') on or near the mechanical structure to at least partially compensate motion generated by the first mentioned actuator (4,6).

Fig. 2

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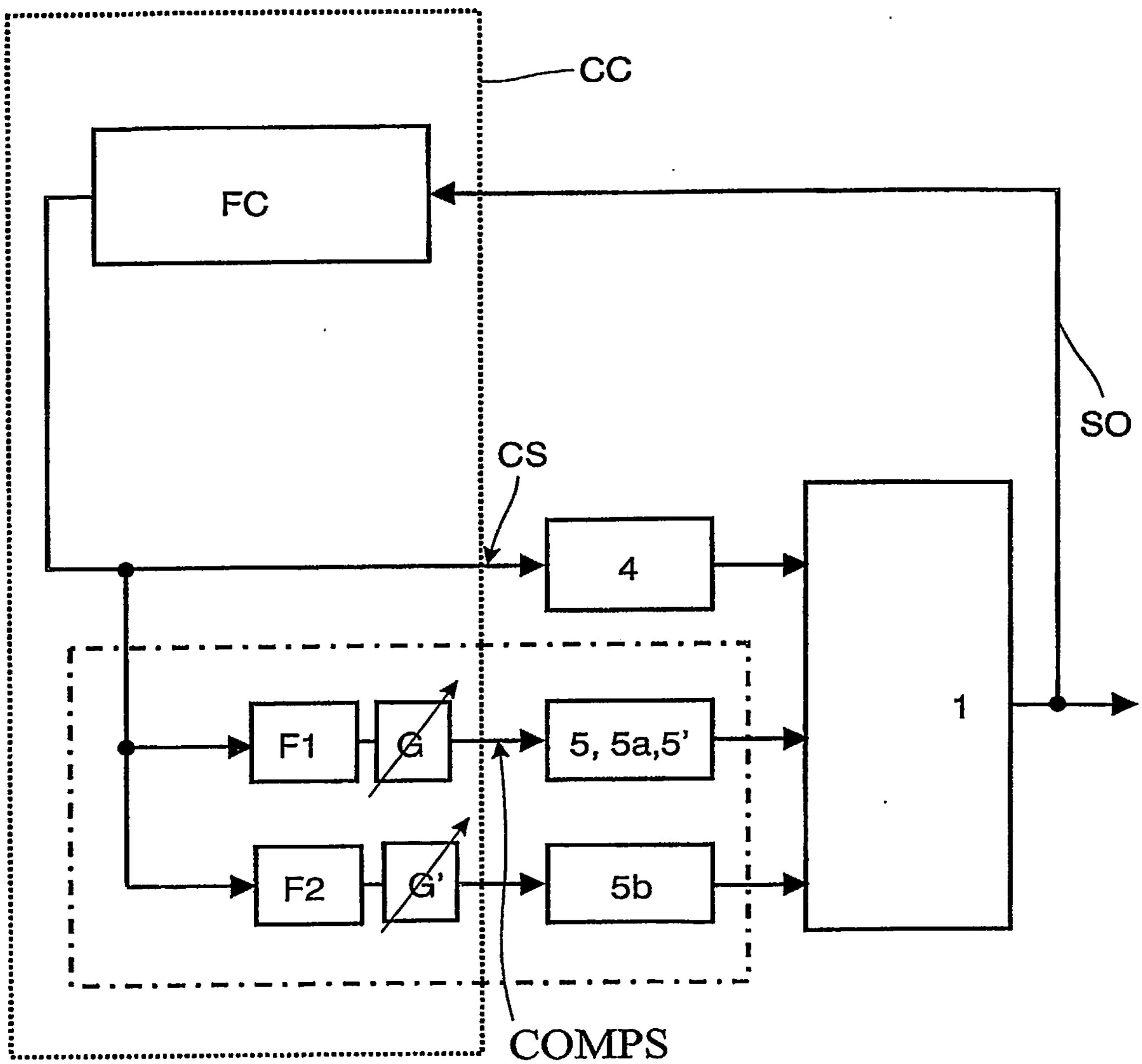


FIG.1

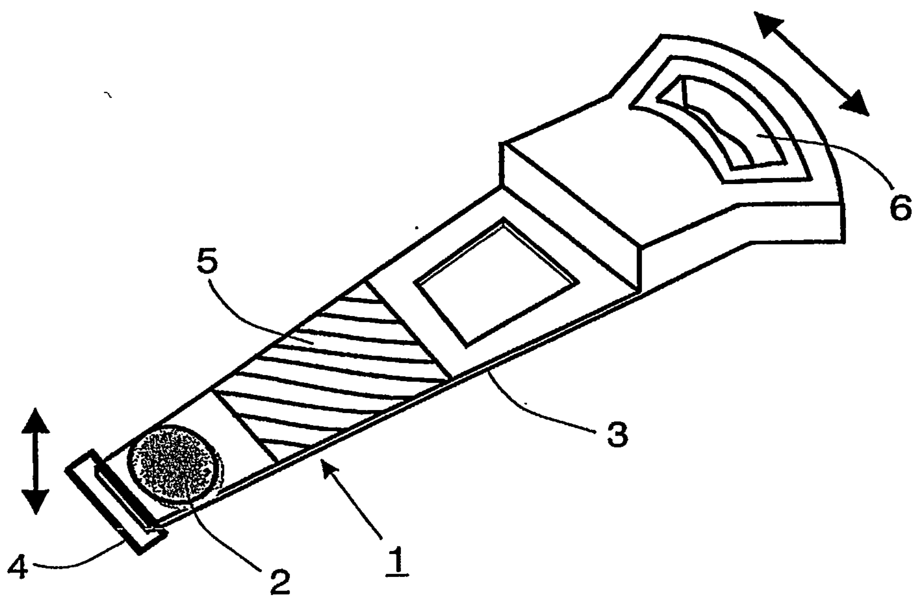


FIG.2

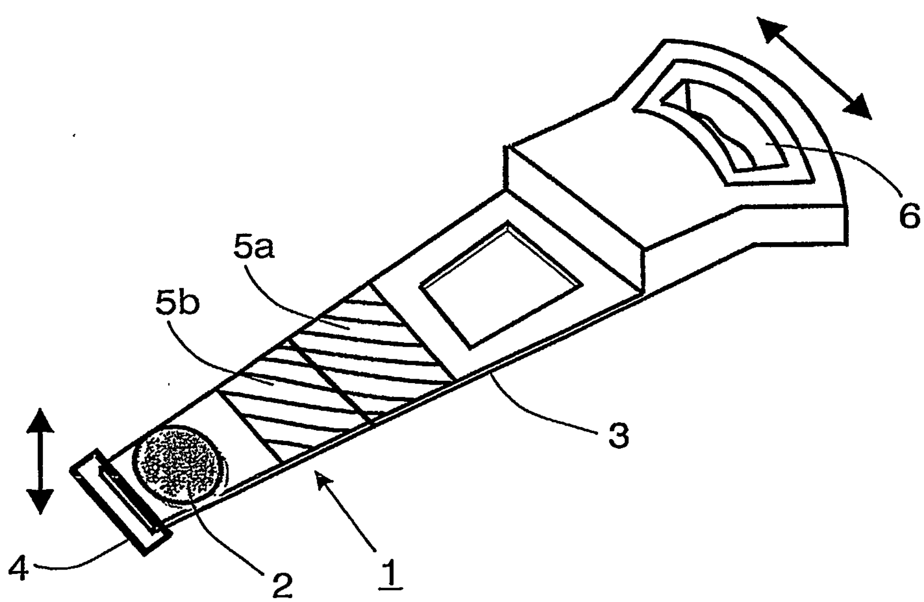


FIG.3

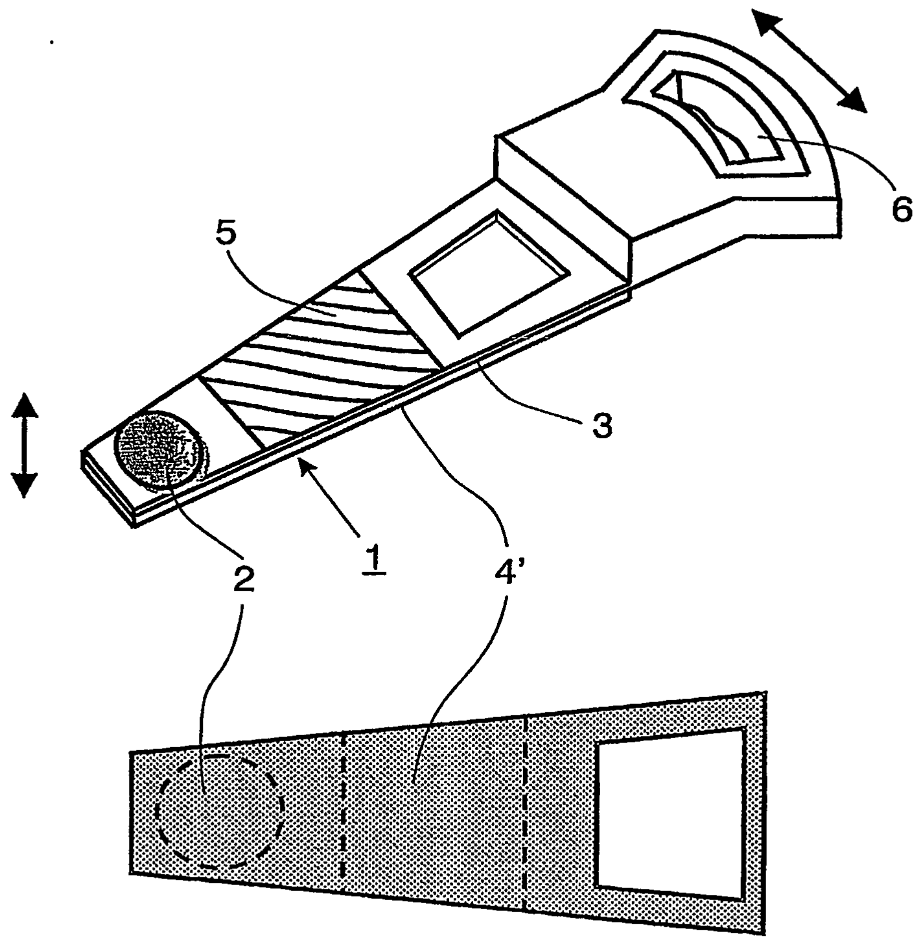


FIG.4

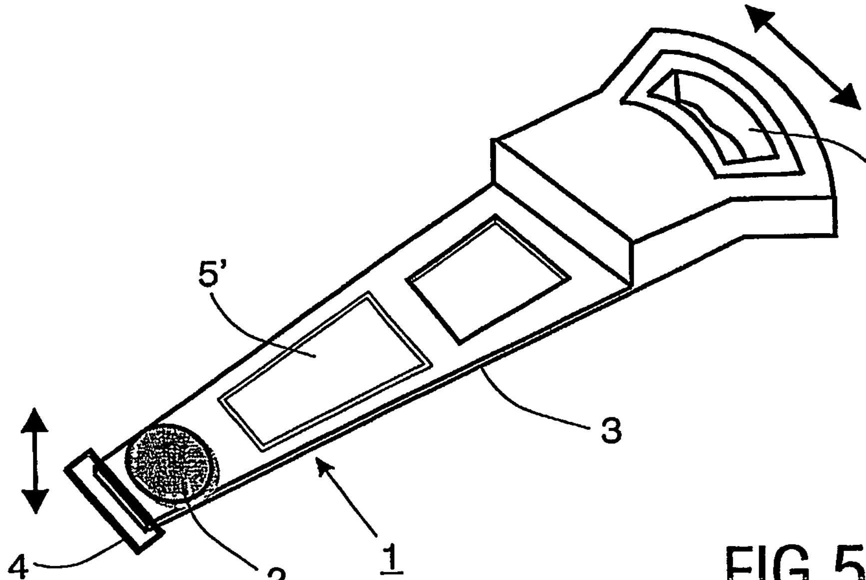


FIG.5

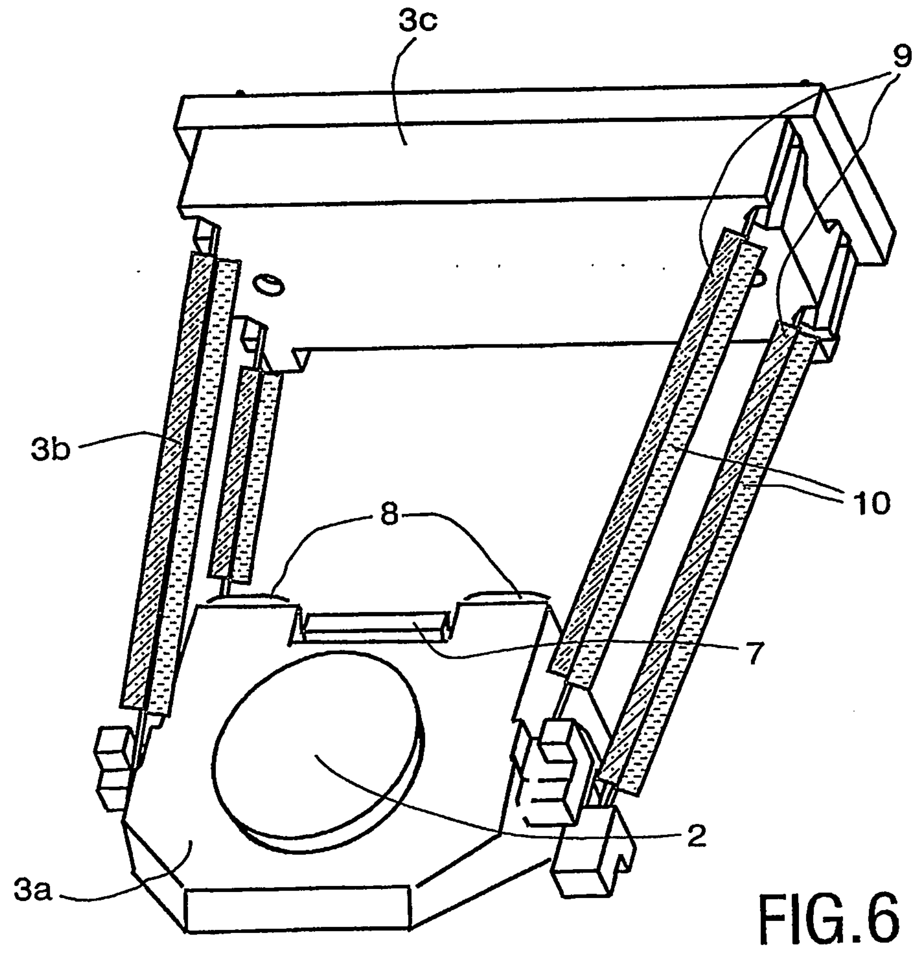
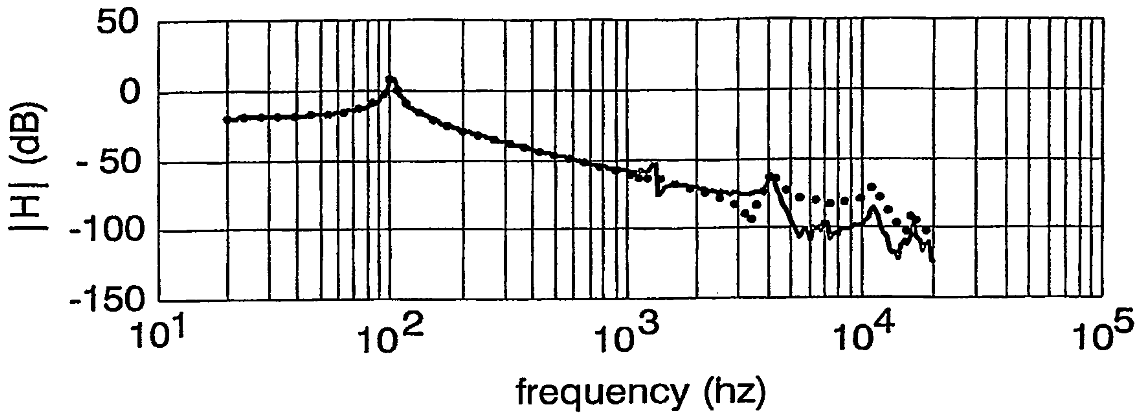
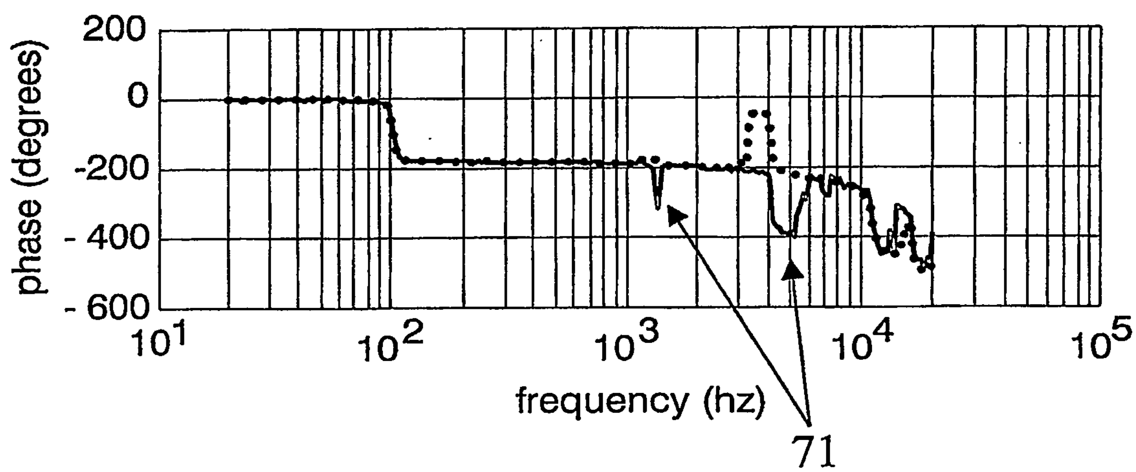


FIG.6



50
0
- 50
-100
-150
|H| (dB)
10^1
10^2
10^3
10^4
10^5
frequency (hz)

FIG.7A



200
0
-200
- 400
- 600
phase (degrees)
10^1
10^2
10^3
10^4
10^5
frequency (hz)
71

FIG.7B